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(71) Applicants  
Zoltan Szirmay,  
7 Szamado utca, H—1016  
Budapest, Hungary,  
Gyula Nagy,  
9 538 utca, H—1173  
Budapest, Hungary  
(72) Inventors  
Zoltan Szirmay,  
Gyula Nagy  
(74) Agent and/or Address for  
Service  
T. Z. Gold and Company,  
9 Staple Inn, London  
WC1V 7QH

## (54) Rotary positive-displacement fluid-machines

(57) A machine of the nutating-disc type that may be adapted for use as an engine or a pump comprises a piston 16 mounted obliquely on a rotary shaft 34 so that relative to the shaft it can revolve about its own axis  $t_2$  while the shaft turns about its axis  $t_1$ . Slotted elements 21 in the piston are disposed radially thereof and engage slidingly with radial blades 28 fixed in a housing structure 2, which has conic inner surfaces 9 and is either fixed or rotates with the shaft.

Ports (29), Fig. 2 (not shown), for the working fluid may be formed in the conic surfaces. Power-transmitting gear-teeth 30 may be attached to the housing structure. When the housing structure is fixed the piston revolves about its axis as it rotates with the shaft and nutates in the housing structure but is fixed relative to the housing structure when the latter rotates with the shaft. Modifications are described with reference to Figs. 4 to 7 (not shown), one modification being such that there are two co-operating pistons in a common housing structure (Fig. 7).

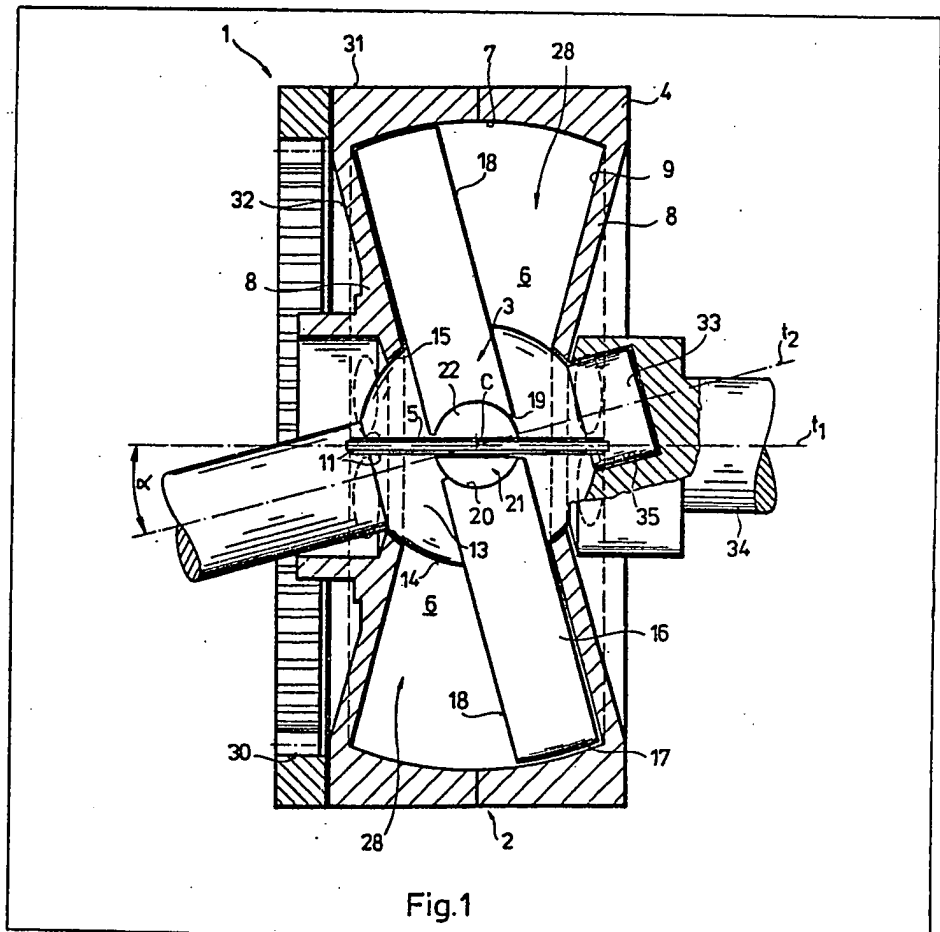
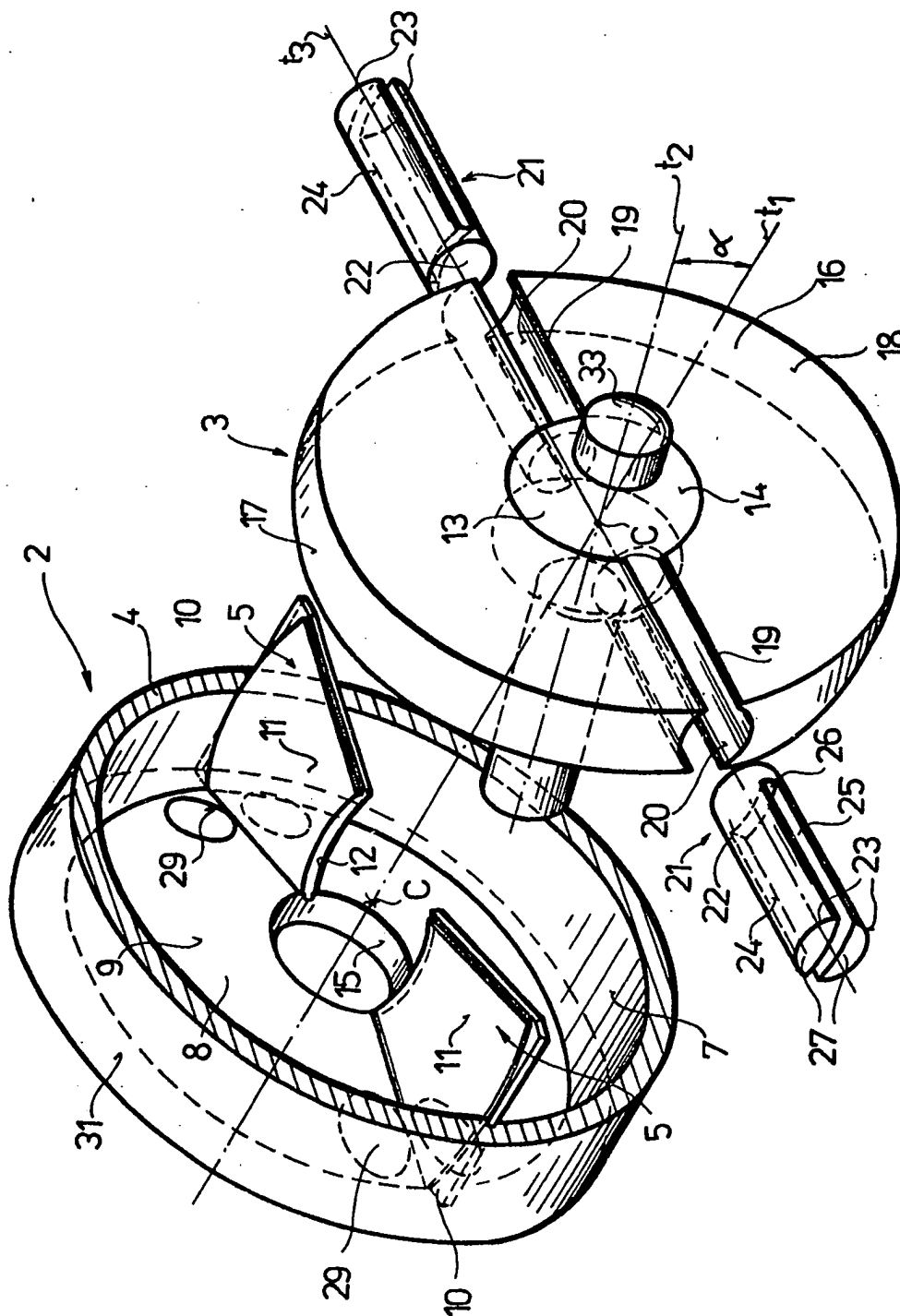


Fig.1





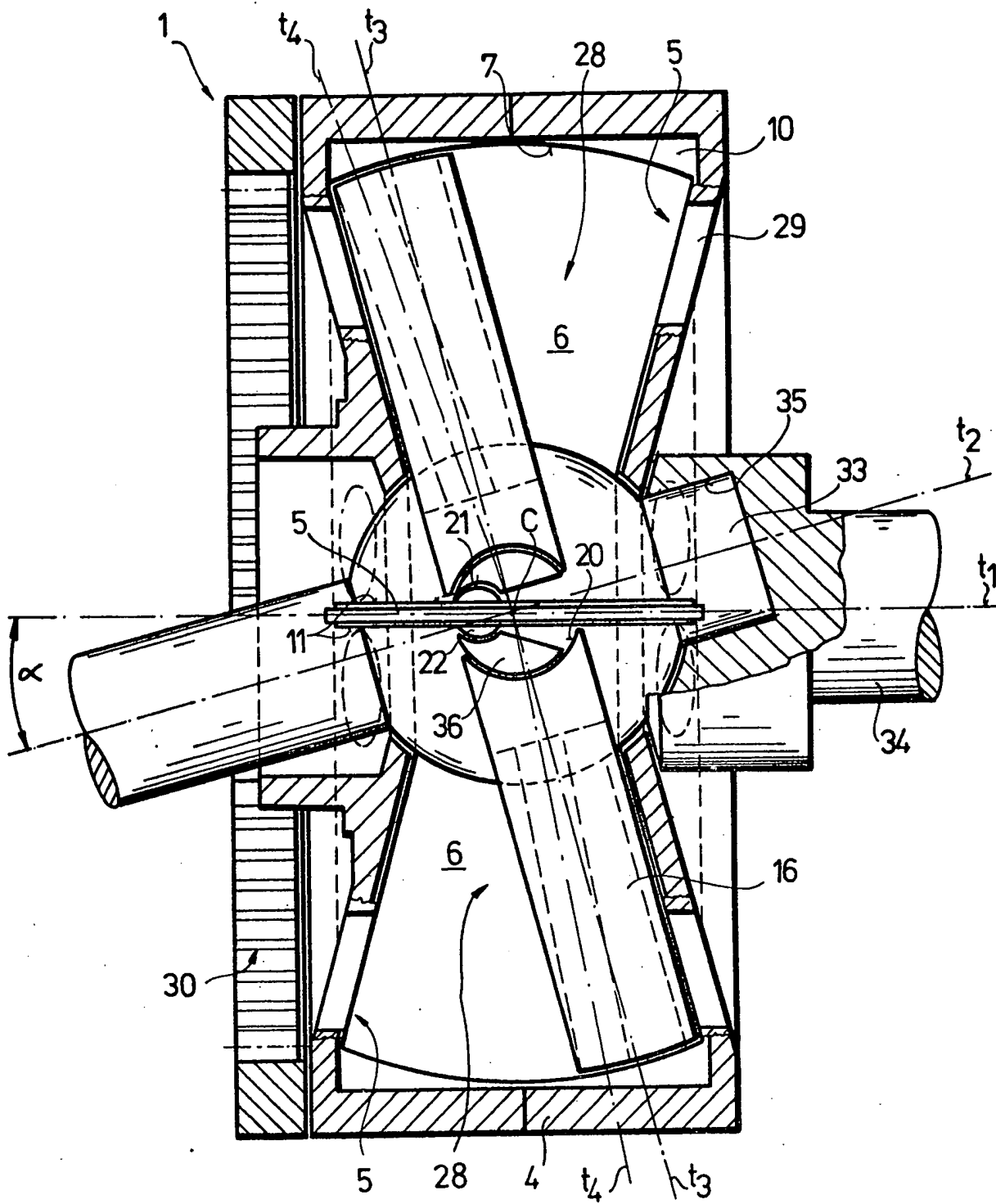
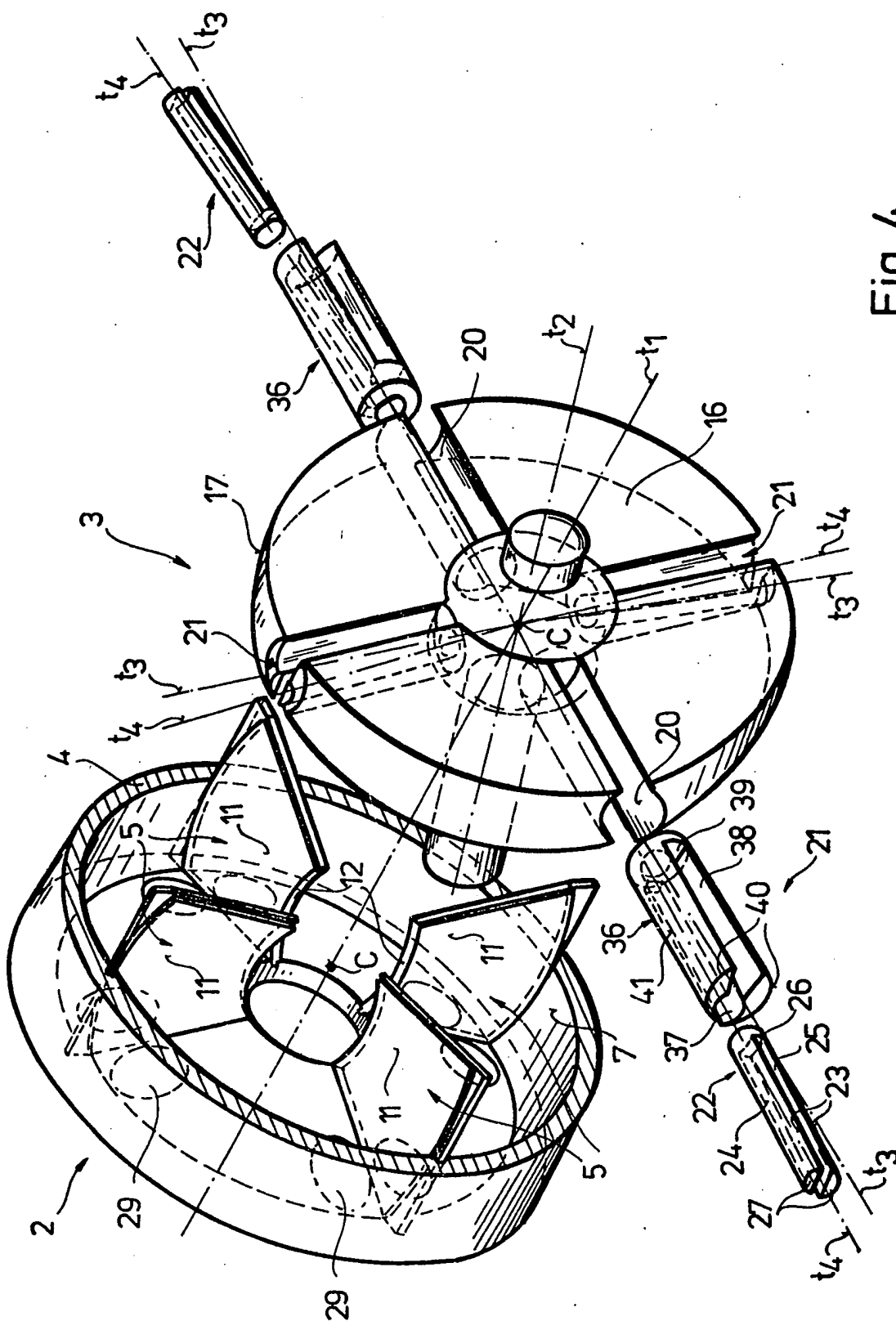


Fig. 3



**Fig. 4**



Fig. 5

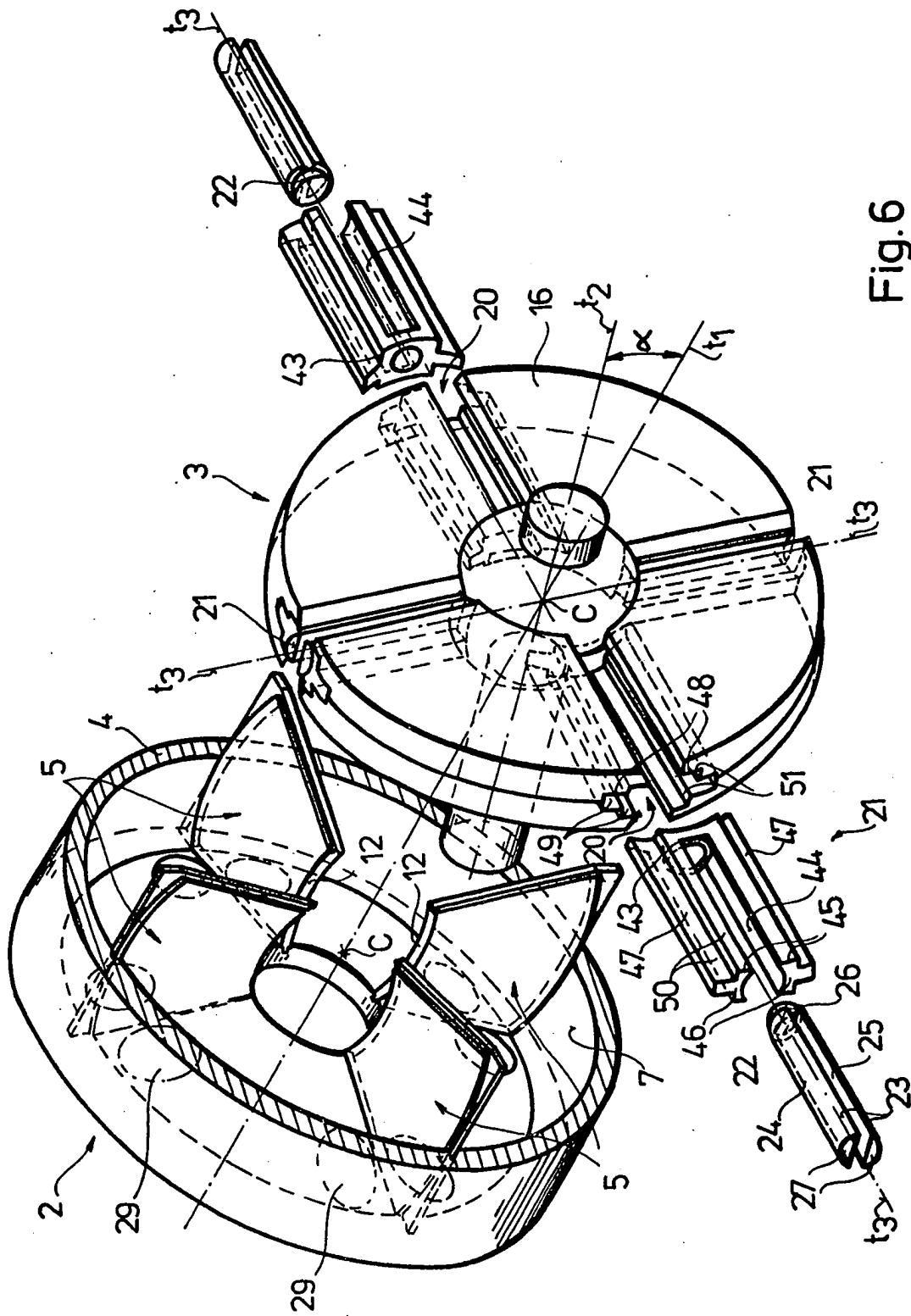


Fig. 6

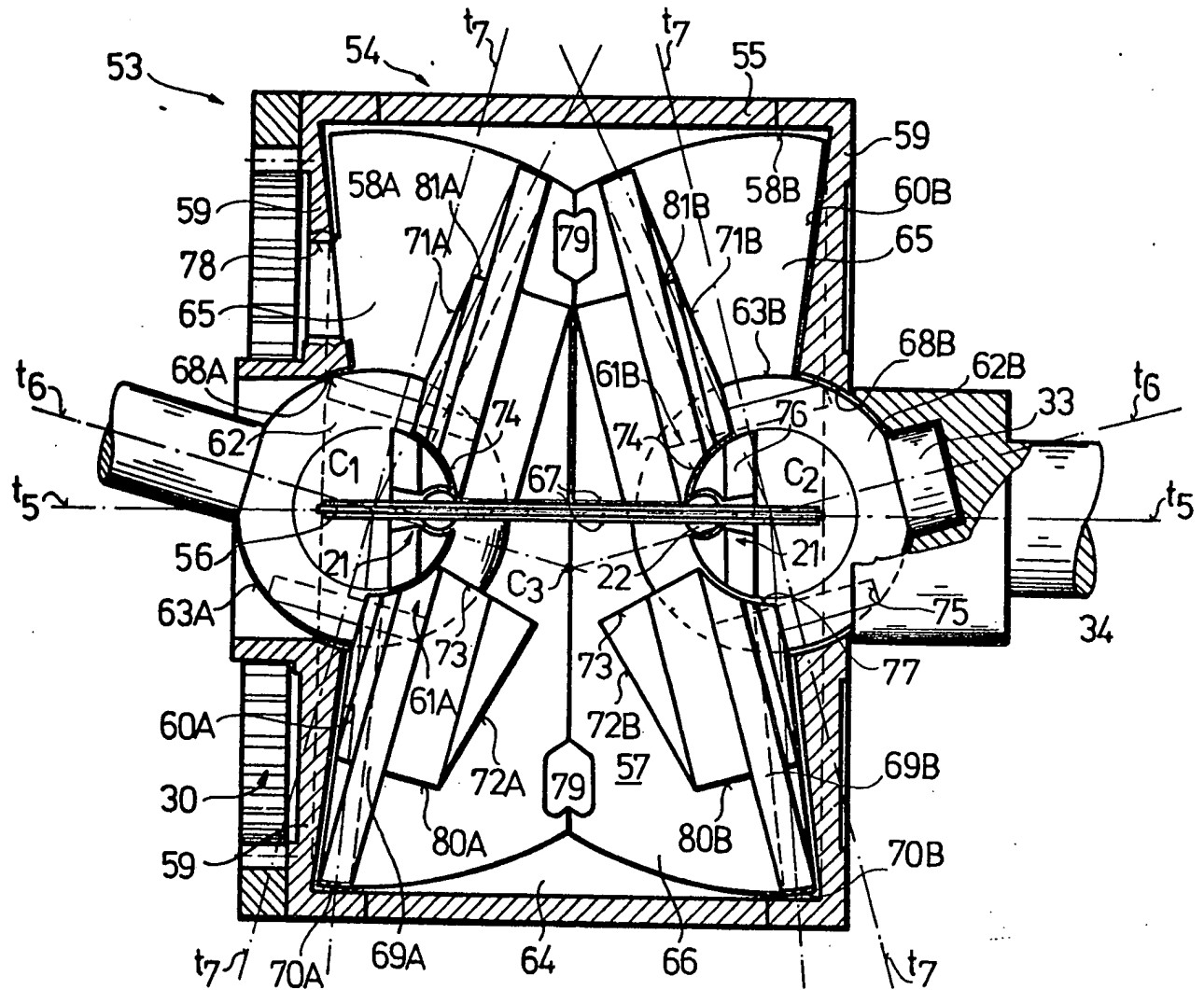


Fig. 7



## SPECIFICATION

## Ball piston construction for machines

The invention relates to ball piston construction for machines e.g. power machines, that is engines or pumps, with two axes of rotation intersecting each other at an angle variable between 0° and approximately 90°; the total inner volume of the ball piston construction is divided into compartments of varying number and compression according to the partition with the aid of blades and motion equalising devices, and the friction and relative displacement of the co-acting devices are minimal.

There are pumps and engines with ball piston, in which the axes of the ball pistons driven in forced coupling intersect each other and the interposed third oscillating piston divides the interior of the pump house confined with spherical surface into compartments. Such solution is described for instance in the US—PS 3 816 038, 3 816 039 and 3 877 850. In these constructions the number of compartments is limited, the elements moving, turning in relation to each other are spherical and cylindrical ensuring relatively favourable machining possibility. On the other hand extraordinary machining and sealing problems appear in the solutions related to slant-axial engines and pumps (GB—PS 1 431 261).

In a further similar solution — described in the FR—PS 2 230 855 — owing to the adverse balance of forces high friction forces arise on the rotary partition walls separating the compartments.

The invention is aimed at the realization of machine family operating at uniform rate with low internal friction, having optional number of compartments by using motion form based on the known slant-axial solutions, which consists of easily producible parts effectively sealable and thus it can be widely used. Further objective was the realization of such solution, when the compression ratio of the compartments is optionally variable.

The objective is attained with a ball piston construction according to the invention, in which the interior of the housing is divided by blades into optional member of compartments, spherically embedded wobbling (swinging) piston is arranged in the housing structure, the piston disc of which divides the interior into compartments of variable volume, and the blades fixed in the housing structure are surrounded with sealed motion equalizing devices fixed in the piston disc.

The invention is a ball piston construction for machines, e.g. engines or pumps, with elements of wobbling motion confining the compartments, provided with medium carrying channels, one of the elements is formed as housing structure, the other one as piston, the interior of the housing of the housing structure is radially arranged being divided into compartments by fixed blades, the interior of the housing is confined by spherical segment-shaped inner faces — the centre of which is the centre of the housing at the same

time — and by such lateral face which is a surface of revolution uniaxial with the said inner face, spherical segment-shaped nest is in the side of the housing the centres of both being the same, the side of the blade confining the compartments is such surface of revolution the axis of which is perpendicular to the axis of the housing and to the central plane of the blade, the inner face of the blade is spherical segment fitted and sealed to the superficies of the piston core, the housing has external power transmitting means, the superficies of the piston core fitted and sealed to the spherical segment surface of the nest in the side of the housing, being a spherical segment the centre of which is identical with that of the housing and has power transmitting means for external connection, the piston has piston disc the superficies of which is spherical segment the centre of which is identical with that of the housing, the lateral faces confining the compartments are surfaces of revolution uniaxial with the piston, the constituent of which is common with that of the lateral faces of the housing, the piston disc has a radial slot receiving the blade, in which motion equalizing device is fitted and sealed rotatably in the nest, the inner faces are fitted and sealed to the lateral faces and inner face of the blade as identical geometrical surfaces, the front faces of the fork shanks are fitted and sealed to the inner face of the housing, furthermore at least one the housing and piston cores has power transmitting means formed as motion transmission at the same time.

The construction according to the invention can have more than two blades, the rotary fork of the motion equalizing device can be arranged in excentric fork, the superficies of the shanks of the excentric fork are fitted into the nest of the slot of the piston disc, the nest is formed by the surface of a body of revolution, axis of the next passes through the centre of the housing, the front face of the fork shanks is fitted and sealed to the inner face of the housing, being a spherical surface having identical centre with the housing, and the axis of the nest fitted to the superficies of the rotary fork shanks intersects the axis of the nest arranged in the excentric fork in the centre of the housing.

In the construction according to the invention suitably with more than two blades, the rotary fork of the motion equalizing device can be arranged in flat fork, the shanks of which have outer guide ribs fitted and sealed into the grooves of the nest of the piston disc having suitable flat lateral faces perpendicular to the axis of the piston disc as to allow its rotation around the axis of the piston disc, the front face of the fork shanks is fitted and sealed to the inner face of the housing as spherical surface having identical centre with that of the housing.

In a twin-pistoned construction according to the invention the spherical segment-shaped superficies confining the interior of the housing consists of two spherical segment surfaces suitably with identical diameter the distance between the centres of which is shorter than the

length of the diameter, and the superficies of each piston disc is in contact with the two spherical segment-shaped superficies. The outer lateral faces of the pistons have conical surfaces of identical bending angle tangential to the plane of truncation of the spherical segment-shaped inner faces of the housing.

The spherical surfaces are theoretical confining surfaces. These are regarded as the surfaces of each element even if they are lightened for instance with parts as body of revolution. The housing and the piston may overstep the limit of the theoretically contacting surface, provided that such cavity is formed on the corresponding contacting surface which receives the profile protruding from one of them and allows the relative displacement arising from the wobbling motion. Such suitable construction form may be for instance when the lateral faces of the piston disc and housing are engaged bevel gear surfaces. Assuming maximum angle between the axes of the housing and piston, the inner faces of the housing and the corresponding lateral faces of the piston disc contact each other in the contacting constituent. If the surfaces at the contacting constituent continuously prevent the flow of medium, then a construction with sealed constituent is brought about. If the flow-through is made possible e.g. with lightening the inner lateral faces of the housing by shaping it as body of revolution, then a construction form with transfer hole will be brought about.

These two alternatives impose different requirements on the formation of the medium carrying channels and flow control elements. In case of construction with transfer hole the requirements of the outlet and inlet holes and control elements are the same as for other machines of limited spatial displacement. In case of construction with sealed constituent, the contacting constituent rolling down on the wall of the compartment — on the inner lateral faces of the housing — divides the space of the compartment into two sectors. At such construction each medium carrying channel has an inlet hole in the vicinity of the blades which holes are ordered to each compartment sector.

The ball pistoned machine according to the invention can be operated in three operation modes, where the relative (mutually) movement of the housing and piston is "wobbling" motion in every case.

In wobbling operation mode the housing is fixed through its power transmission means, the power transmission means of the piston is motion transmission at the same time, which rotates the shaft of the piston around conical superficies (in pump and compressor operation), or which is forced to rotate by the shaft of the piston rotating on the conical superficies (in engine and hydro-engine operation).

In rotating operation mode the motion transmission means of the piston is fixed, and the piston embedded in the motion transmission means rotates around its axis together with the

housing. The power transmission means of the housing is formed as a motion transmission at the same time which drives the housing (in pump operation) or which is forced to rotate by the housing (in engine, hydro-motor operation).

In the third combined operation mode the power transmission means of the housing and piston are formed as motion transmission at the same time, being in forced driving coupling.

In the above three different operation modes the conditions and possibilities of the construction of the medium carrying channels and flow control elements vary.

In wobbling operation mode the medium carrying channels and the openings leading into the compartments can be most favourably formed in the stationary housing.

In rotating operation mode the medium carrying channels are formed most suitably in the stationary element incorporating the rotary housing, to which the outer surface of revolution of the housing is fitted and sealed and the openings of the compartments perform the task of control as well.

In the combined operation mode the conditions of forming the medium carrying channels are similar to those existing in the rotating operation mode.

#### Brief Description of the Drawings

The invention is described in detail with the aid of drawings by way of four examples, in which:

Figure 1: axial section of the first embodiment of ball piston construction according to the invention,

Figure 2: isometric (axonometric) view of the elements of the construction according to Figure 1,

Figure 3: axial section of the second embodiment,

Figure 4: isometric view of the elements of the construction according to Figure 3,

Figure 5: axial section of the third embodiment,

Figure 6: isometric view of the elements of the construction according to Figure 6,

Figure 7: axial section of the fourth embodiment of the invention.

#### Description of the Preferred Embodiments

In the first example shown in Figures 1 and 2, one of the wobbling elements of a ball pistoned construction 1, e.g. power machine with sealed constituent is formed by a housing structure 2, the other one by a piston 3. The housing structure 2 has a housing 4 and blades 5 fixed in the housing 4. Interior 6 of the housing 4 is confined by spherical segment-shaped inner faces 7 and inner lateral faces 9 of sides 8. Centre C and axis  $t_1$  of the spherical segment-shaped inner faces 7 form the centre and axis of the housing 4 as well. The inner lateral faces 9 are surfaces of revolution formed by constituent rotated around axis  $t_1$ , in this example being conical surfaces. The constituent may be optional curve, provided that it is contacted or intersected in one point only by an

arc having common centre C with the housing 4.

The blades 5 are fitted and sealed to the inner faces 7 and inner lateral faces 9, and are radially arranged in grooves 10 of the housing 4

5 (Figure 2). Lateral faces 11 of the blades 5 may be surfaces of revolution the axis of which is perpendicular to the axis of housing 4 and to the medium plane of the blade 5, but they are flat surfaces in this embodiment. An inner end face 12 of the blade 5 is spherical segment-shaped surface fitted and sealed to a spherical segment-shaped superficies 14 of a piston core 13 of the piston 3. The superficies 14 of the piston core 13 is fitted and sealed in a spherical segment-shaped nest 15 formed in the sides 8 of the housing 4, the centre and axis of which are common with centre C and axis  $t_1$  of the housing 4.

The piston core 13 of the piston 3 forms a single piece with a piston disc 16, the superficies 14 of which is fitted and sealed to the inner face 7 of the housing 4 as a spherical segment-shaped surface with identical centre C. A front face of the piston disc 16 is marked with 17. Lateral faces 18 of the piston disc 16 are surfaces of revolution having common axis  $t_2$  with the piston 3 the constituent of which is common with that of the inner lateral faces 9 of the housing 4. In this embodiment the constituent is straight section, the lateral faces 18 are flat surfaces.

The piston disc 16 has slots 19 receiving the blades 5, in which radial nests 20 are formed for motion equalizing devices 21. The geometrical axis of the radial nest 20 as surface of revolution passes through the centre C.

The motion equalizing device 21 is formed as rotary fork 22 (Figure 2). Outer revolution surface 24 of fork shanks 23 of the rotary fork 22 is fitted and sealed into the radial nest 20 of the piston disc 16 as to allow its swing; inner faces of the fork shanks 23, to bottom surface 26 and inner lateral faces 25 seal and surround the lateral faces 11 of the blade 5, and the bottom surface 26 is fitted and sealed to the inner end face 12 of the blade 5. The inner lateral faces 25 and the lateral faces 11 as well as the bottom surface 26 and inner end face 12 are identical geometrical surface-pairs. Front faces 27 of the fork shanks 23 are spherical segment-shaped surfaces with centre C fitted and sealed to the inner face 7 of the housing 4.

In the present embodiment two opposite blades 5 of identical medium plane are in the housing 4, which divide the interior 6 into four compartments 28. In operation the sealed lateral faces 18 of the piston disc 16 roll down and slide the inner lateral faces 9 of the housing 4.

In this embodiment the lateral faces 9 and 18 are in contact with each other. Each compartment 28 has at least two medium carrying channels 29 formed (inlet or outlet) in the side 8 of the housing 4 in the vicinity of the blades 5 (Figure 2). The channels 29 are interconnected with supply and discharge channels and control elements (not shown), the latter ones formed as simple snuffle valves.

The housing 4 has a power and motion transmission means which is provided with a gear rim 30. A superficies 31 and outer lateral faces 32 of the housing 4 are surfaces of revolution, axis  $t_1$ , thus the ball piston construction 1 is suitable for incorporation as rotor in the machine body provided with medium carrying channels connected to the channels 29 and control elements (not shown).

The piston core 13 of the piston 3 is provided with trunnion 33, which forms power and motion transmitting means with an oblique-bored shaft 34, in which the axis of a hole 35 receiving the trunnion 33 is at an angle  $\alpha$  to the axis of rotation  $t_1$  of the oblique-bored shaft 34.

The ball piston construction according to Figures 1 and 2 may be operated as pump, if the medium carrying channels (not shown) connected to the channels 29 of the housing 4 are provided with medium control elements, e.g. with snuffle valves. In this case the housing 4 is fixed against turn through its power transmission means such as the gear rim 30. The oblique-bored shaft 34 turned around the axis  $t_1$  rotates the trunnion 33 that is bearing supported in hole 35, the axis of rotation of which  $t_2$  — as the axis of the piston 3 revolves around a conical surface at half-angular subtense  $\alpha$ . Meanwhile the piston 3 performs wobbling motion around the ball centre C, whereby the rotary fork 22 arranged in the radial nest 20 performs  $\pm\alpha$  angular displacement relatively to the piston disc 16. On the other hand, the rotary fork 22 performs  $\pm\alpha$  angular displacement around the ball centre C along the plane of the blade 5. Each constituent of the lateral faces 18 of the piston disc 16 are in contact with each constituent of the inner lateral faces 9, the surfaces rolling and sliding on each other. During the wobbling motion of the piston disc 16 the volume of each compartment 28 varies between 0 and the maximum value. Until the volume of the compartment 28 increases, it sucks in medium through the corresponding channel 29 according to the direction of rotation, then the volume of the compartment 28 decreases and the medium flows out through the corresponding channel 29.

Rotating operation is also realizable, since the superficies 31 and the lateral faces 32 of the housing 4 are surfaces of revolution, thus the housing 4 is suitable for building in as rotor into the stationary housing and for rotating it with driving mechanism through the gear rim 30. The medium carrying channels of the stationary housing (not shown) with the rotating channels 29 perform the control of the flow of medium. When the housing 4 is rotated, the wobbling motion of the piston 3 — as the required operation — is realized, provided that the oblique-bored shaft 34 is fixed against rotation, because in that case the trunnion 33 and the piston 3 rotate with the housing 4 around the axis of rotation  $t_2$ .

The second embodiment of the ball piston construction 1 with sealed constituent according to the invention shown in Figures 3 and 4 differs

from the construction according to Figures 1 and 2 in the number of the blades 5 and compartments 28, and in the construction of the motion equalizing device 21.

- 5 In this case the number of the blades 5 is four spaced at  $90^\circ$ . The motion equalizing device 21 has a rotary fork 22. The inner faces of fork shanks 23 of the rotary fork 22, so the bottom surface 26 and the inner lateral faces 25 are sealed and
- 10 surround the lateral faces 11 of the blade 5, and the bottom surface 26 is sealed and fitted to the inner end face 12 of the blade 5. The inner lateral faces 25 and lateral faces 11 as well as bottom surface 26 and inner end face 12 are identical
- 15 surface-pairs. The front faces 27 of fork shanks 23 of the rotary fork 22 are also spherical segment shaped surfaces with centre C, sealed and fitted to the inner face 7 of the housing 4. The outer
- 20 revolution surface 24 of the fork shanks 23 is fitted and sealed — allowing rotation — into a radial nest of an excentric fork 36 formed in a slot 38 of the excentric fork 36. The radial nest is shaped as a revolution surface 37, its axis  $t_4$  passes through the ball centre C. A bottom surface
- 25 39 of the slot 38 is a spherical segment-shaped surface with ball centre C fitted and sealed to the inner end face 12 of the blade 5. An outer revolution surface 41 of a fork shanks 40 of the excentric fork 36 is fitted into the radial nest 20 of the piston disc 16. The axis of the outer revolution surface 41 of the fork shanks 40 coincides with the axis  $t_3$  of the radial nest 20 passing through the ball centre C. Front face 42 of the fork shanks 41 is a spherical segment-shaped surface with the
- 30 ball centre C fitted and sealed to the inner face 7 of the housing 4.

- The construction according to the second embodiment functions similarly to the one according to Figures 1 and 2, the difference is only
- 40 in the operation of the motion equalizing device 21. Since the number of equally spaced blades 5 is four, thus during the relative wobbling motion not only the rotary fork 22 but the excentric fork 36 too rotates around their axes in relation to the
- 45 piston 3, whereby the angle of axes  $t_4$  of the two adjacent rotary forks 22 varies.

- The third embodiment of the ball piston construction with sealed constituent according to the invention shown in Figures 5 and 6, differs
- 50 from the one according to the second embodiment in the motion equalizing device 21.

- The motion equalizing device 21 has also a rotary fork 22. The inner faces of the fork shanks 23 of rotary fork 22, so the bottom surface 26 and the inner lateral faces 24 are sealed and surround the lateral faces 11 of blade 5, and the bottom surface 26 is fitted and sealed to the inner end face 12 of the blade 5. The inner lateral faces 25 and lateral faces 11 as well as the bottom surface
- 55 26 and inner end face 12 are identical surface-pairs. The front faces 27 of the fork shanks 23 of the rotary fork 22 are spherical segment-shaped surfaces with centre C, sealed and fitted to the inner face 7 of the housing 4. The outer rotation
- 60 surface 24 of the fork shanks 23 is fitted and

- sealed — allowing rotation — into a radial nest 44 of a flat fork 43, the axis  $t_3$  of said nest passes through the ball centre C, perpendicular to the axis  $t_2$  of the piston 3 and formed as surface of revolution. A front faces 46 of a fork shanks 45 of flat fork 44 are spherical segment-shaped surfaces with ball centre C, fitted and sealed to the inner face 7 of the housing 4. The fork shanks 45 have outer guide ribs 47 fitting into grooves 48 of the
- 70 radial nest 20 of the piston disc 16. Lateral faces 49 of the grooves 48 are surfaces of revolution — flat surfaces in this example — the axis of which is identical with the axis  $t_2$  of the piston disc 16. Lateral faces 50 of the identically formed outer
- 80 guide ribs 47 are fitted and sealed to the flat surfaces of the grooves 48. The flat fork 43 is capable to turn around the axis  $t_2$  of the piston disc 16 to a limited extent, the turn being limited by a contact surfaces 51 of the radial nest 20 and
- 85 by an outer front faces 52 forming the counterfaces of the flat fork 43.

- The construction according to Figures 5 and 6 functions similarly to the one given in the second embodiment, the difference is only in the motion equalizing device 21. In this case too the angle of the axis of the two adjacent rotary forks 22 varies during the relative wobbling motion of the piston 3, since the two adjacent flat forks 43 in which the rotary forks 22 are arranged approach or move off each other by turning around axis  $t_2$  along the plane perpendicular to axis  $t_2$  of the piston 3. Thus the outer guide ribs 42 of the fork shanks 45 of the flat fork 43 slide tangentially in the groove 48 of the radial nest 20 of the piston disc 3.

- A further embodiment of the ball piston construction according to the invention shown in Figure 7 is formed as twin-pistoned power machine 53 with transfer port. The twin-pistoned power machine 53 has a housing structure 54,
- 100 housing 55 and two blades 56 fixed in the housing 55. The interior 57 of the housing 55 is confined by spherical segment-shaped inner faces  $58_A$  and  $58_B$  adjoining each other and by inner lateral faces  $60_A$  and  $60_B$  of sides 59.

- The distance between centres  $C_1$  and  $C_2$  of the inner faces  $58_A$  and  $58_B$  is less, than the length of diameter of the inner faces  $58_A$  and  $58_B$ , but greater than the distance given by the sum of the radii of superficies  $63_A$  and  $63_B$  of piston cores
- 115  $62_A$  and  $62_B$  of piston  $61_A$  and  $61_B$ . Axis  $t_5$  of the housing 55 passes through centres  $C_1$  and  $C_2$ . The inner lateral faces  $60_A$  and  $60_B$  are surfaces of revolution formed by the constituent turned around axis  $t_5$  in this case are conical surfaces. The blades 56 fitted and sealed into the grooves 64 of the inner faces  $60_A$  and  $60_B$ , the superficies  $58_A$  and  $58_B$ . Axis  $t_5$  of the housing 55 is in the medium plane of the blades 56. Lateral faces 67 of the blades 56 surrounding compartments 65
- 120 and 66 are surfaces of revolution — flat surfaces in this example — the axis of which is perpendicular to the axis  $t_5$  of the housing 55 and to the medium plane of the blade 56.

- The two identical pistons  $61_A$  and  $61_B$  are built
- 130 into the housing 55. Each piston core  $62_A$  or  $62_B$

of the piston 61<sub>A</sub> or 61<sub>B</sub> has spherical segment-shaped superficies 63<sub>A</sub> or 63<sub>B</sub> fitted into a spherical segment-shaped nest 68 of the sides 59 of the housing 55, the centres of which are C<sub>1</sub> and C<sub>2</sub>. The piston core 62<sub>A</sub> or 62<sub>B</sub> of each piston 61<sub>A</sub> or 61<sub>B</sub> forms a single piece with a piston disc 69<sub>A</sub> or 69<sub>B</sub> superficies 70 of which is a spherical segment-shaped surface with centres C<sub>1</sub> and C<sub>2</sub> fitted and sealed into the inner face 59 of the housing 55. Lateral face 71<sub>A</sub> or 71<sub>B</sub> of each piston disc 69<sub>A</sub> or 69<sub>B</sub> facing the inner lateral face 60<sub>A</sub> or 60<sub>B</sub> is a surface of revolution, the axis of which is identical with axis t<sub>6</sub> of the piston 61<sub>A</sub> or 61<sub>B</sub> and its constituent is common with that of the inner lateral face 60<sub>A</sub> or 60<sub>B</sub>. In this example the constituent is straight, the lateral face 71<sub>A</sub> or 71<sub>B</sub> is conical surface, the bending angle is identical with that of the inner lateral face 60<sub>A</sub> or 60<sub>B</sub>. An other lateral face 72<sub>A</sub> or 72<sub>B</sub> of the piston disc 69<sub>A</sub> or 69<sub>B</sub> is formed similarly as a conical surface, its axis is identical with the axis t<sub>6</sub> of the piston 61<sub>A</sub> or 61<sub>B</sub>, the conical surface has straight constituent. The two pistons 61<sub>A</sub> and 61<sub>B</sub> are formed and arranged in the housing 55 in such a manner that the apexes of the lateral faces 72<sub>A</sub> and 72<sub>B</sub> coincide (in the centre C<sub>3</sub>). The lateral faces 72<sub>A</sub> and 72<sub>B</sub> of the piston disc 69<sub>A</sub>, 69<sub>B</sub> respectively are provided with cylindrical parts 80<sub>A</sub>, 80<sub>B</sub> respectively.

Slots 73 receiving the blades 56 are in the piston discs 69<sub>A</sub> and 69<sub>B</sub>, in which radial nests 74 are formed for the motion equalizing devices 21. The axis t<sub>7</sub> of the radial nest 74 formed as surface of revolution passes through centre C<sub>1</sub>. The motion equalizing device 21 is formed in this case as an excentric fork 76 and as the rotary fork 22 arranged within. The lower part of the radial nest 74 is a blind hole 75 machined in the piston core 62, its upper part is cylindrical surface 77 machined in piston disc 69<sub>A</sub> or 69<sub>B</sub>. Construction and function of the motion equalizing device 21 are the same as described in Figures 3 and 4.

The interior 57 of the housing 55 is divided into the compartments 65 and 66 by the blades 56 and the pistons 61<sub>A</sub> and 61<sub>B</sub>. The compartment 65 is formed between the inner lateral face 60 of the housing 55 and the lateral faces 71<sub>A</sub> and 71<sub>B</sub> of the pistons 61<sub>A</sub>, 61<sub>B</sub>. The actuating medium connection of the compartment 65 is formed as a port 78 on the side 59 of the housing 55, and the medium connection of the compartment 66 is formed as a port 79 leading to the superficies 58 of the housing 55.

The exterior of the housing 55 is formed the same way as in the first embodiment, both the housing 55 and the piston 61 have the same power and motion transmitting means.

The compartments 65 of the construction according to Figure 7 function the same way, as the compartments 28 in Figures 1 and 2.

Operation of the compartment 66 is determined by the joint relative wobbling motion of piston discs 69<sub>A</sub> and 69<sub>B</sub> of the two pistons 61<sub>A</sub> and 61<sub>B</sub>. Volume of said compartment varies between 0 and maximum value. Until the volume

of the compartment increases, it sucks in the medium through the corresponding port 79 — depending on the direction of rotation — then the volume decreases and the medium flows out of the compartment 66 through the corresponding port 79.

The twin-pistoned power machine 53 similarly to the former embodiments can be operated in wobbling, rotary and combined operation modes.

In the annexed claims reference numbers have been used purely by way of example and aiding understanding but not of limitation of scope.

#### List of the Reference Numbers

	1 ball piston construction
	2 housing structure
	3 piston
	4 housing
	5 blade
	6 interior
80	7 spherical segment-shaped inner face
	8 side
	9 inner lateral face
	10 groove
	11 lateral face
85	12 inner face
	13 piston core
	14 spherical segment-shaped superficies
	15 nest
	16 piston disc
90	17 front face
	18 lateral face
	19 slot
	20 radial nest
	21 motion equalizing device
100	22 rotary fork
	23 fork shank
	24 outer revolution surface
	25 inner lateral face
	26 bottom surface
105	27 front face
	28 compartment
	29 channel
	30 power and motion transmission means/gear rim
110	31 superficies
	32 outer lateral face
	33 trunnion
	34 oblique-bored shaft
	35 hole
115	36 excentric fork
	37 revolution surface
	38 slot
	39 bottom surface
	40 fork shank
120	41 outer revolution surface
	42 front face
	43 radial nest
	44 flat fork
	45 fork shank
125	46 front face
	47 outer guide rib
	48 groove
	49 lateral face
	50 lateral face

- 51 contact surface
- 52 outer front face
- 53 twin-pistoned power machine
- 54 housing structure
- 5 housing
- 56 blade
- 57 interior
- 58<sub>A</sub>, 58<sub>B</sub> inner faces
- 59 side
- 10 60<sub>A</sub>, 60<sub>B</sub> inner lateral faces
- 61<sub>A</sub>, 61<sub>B</sub> pistons
- 62<sub>A</sub>, 62<sub>B</sub> piston cores
- 63<sub>A</sub>, 63<sub>B</sub> superificies
- 64 groove
- 15 65 compartment
- 66 compartment
- 67 lateral faces
- 68 nest
- 69<sub>A</sub>, 69<sub>B</sub> piston disc
- 20 70<sub>A</sub>, 70<sub>B</sub> superficies
- 71<sub>A</sub>, 71<sub>B</sub> lateral face
- 72<sub>A</sub>, 72<sub>B</sub> lateral face
- 73 slot
- 74 radial nest
- 25 75 blind hole
- 76 excentric fork
- 77 cylindrical surface
- 78 port
- 79 port
- 30 80<sub>A</sub>, 80<sub>B</sub> cylindrical ports

# CLAIMS

- 1. Ball piston construction for machines, e.g. machines or pumps, provided with compartment-confining elements in relative wobbling motion and with a medium-carrying channel, one of them
- 35 formed as housing structure, the other one as a piston, or pistons, wherein the interior of the housing is radially arranged and divided into compartments by fixed blades,
- 40 the interior of the housing is confined by at least one spherical segment-shaped inner face, the centre of which forms the centre of the housing and by a lateral face which is surface of revolution co-axial with axis ( $t_1$ ,  $t_5$ ) of said inner
- 45 face,
- a spherical segment-shaped nest is formed in the side of the housing, the centre of which is the same as the centre ( $C$ ,  $C_1$ ,  $C_2$ ) of the inner face of the housing,
- 50 a lateral face of each blade confining the compartments is a surface of revolution, the axis of which is perpendicular to the axis ( $t_1$ ,  $t_5$ ) of the housing and to the median plane of the blades, an inner end face of each blade is a spherical
- 55 segment fitting to a surface of a piston core of the piston,
- the housing is provided with an external power-transmitting means, the surface of the piston core is a spherical segment having an identical centre
- 60 ( $C$ ,  $C_1$ ,  $C_2$ ) with and fitted and sealed to the spherical segment-shaped surface of the nest in the side of the housing and has power-transmitting means for external connection,
- the piston has a piston disc the surface of

- 65 which is a spherical segment fitted and sealed to inner face of the housing having a common centre ( $C$ ,  $C_1$ ,  $C_2$ ),
- the lateral faces of the blades confining the compartments are surfaces of revolution co-axial
- 70 ( $t_2$ ,  $t_6$ ) with the piston; the piston disc has radial slots (19, 73) receiving the blades and in each said slot a radial nest is formed for a motion-equalizing device,
- in said nest a fork-shaped motion-equalizing
- 75 device is fitted and sealed through its surface allowing angular displacement around axis ( $t_3$ ) perpendicular to axis ( $t_2$ ) of the piston in the median plane of the blade; its inner faces are fitted and sealed to the lateral faces of the blades and
- 80 the inner end face has identical geometrical surfaces with them,
- the front faces of the fork shanks are fitted and sealed to the inner face of the housing,
- furthermore at least one of the transmitting
- 85 means of the housing and of the piston is formed so as to be suitable for motion transmission at the same time.
- 2. Ball piston construction as claimed in claim 1, wherein the medium-carrying channels
- 90 leading into the compartments are formed as perforations in the wall of the housing, the surface of which is surface of revolution suitable for sealing, and the power-transmitting means (30) of the housing is formed to be suitable for motion
- 95 transmission.
- 3. Ball piston construction as claimed in claim 1, wherein the housing has two opposite
- 100 blades with the same median plane and its motion-equalizing device is formed as a rotary fork, the surface of the fork shanks are surfaces of revolution fitting into the radial nest formed as surface of revolution in the slot of the piston disc, the axis ( $t_3$ ) of which passes through the centre ( $C$ ) of the housing.
- 105 4. Ball piston construction as claimed in claim 2, wherein the rotary fork of the motion-equalizing device (21) is arranged in an eccentric fork; surfaces (41) of the fork shanks of the eccentric fork fit into the radial nest formed as
- 110 surface of revolution in the slot of the piston disc, the axis ( $t_3$ ) of the radial nest passes through the centre ( $C$ ) of the housing, the front faces (42) of the fork shanks (40) are fitted and sealed to the inner face of the housing; the axis ( $t_3$ ) of the radial
- 115 nest — fitting to the spherical surface the centre of which is identical with that of the housing and to the surfaces of the fork shanks of the rotary fork — intersects the axis ( $t_4$ ) of a nest in an eccentric fork in the centre ( $C$ ) of the housing (4).
- 120 5. Ball piston construction as claimed in claim 2, wherein the rotary fork of the motion-equalizing device is arranged in a flat fork the fork shanks of which have external guide ribs fitting into grooves of the radial nest of the piston disc being rotatable around the axis ( $t_2$ ) of the piston, having flat lateral faces suitably perpendicular to the axis ( $t_2$ ) of the piston disc (16), and a front face
- 125 (46) of the fork shanks as spherical surface having an identical centre ( $C$ ) with the housing is fitted

and sealed to the inner face of the housing (4).

6. Ball piston construction as claimed in claim 1, wherein a jacket confining the interior of the housing is a spherical segment-shaped inner face suitably with an identical diameter, the distance between the centres ( $C_1$ ,  $C_2$ ) is less than the length of diameter of the inner face, but greater than the distance given by the sum of the radii of surfaces of the pistons (61) fitting each spherical segment-shaped surface.

7. Ball piston construction as claimed in claim 6, wherein an opposite arranged lateral faces of the piston disc of the pistons surround the compartment, the connection of the actuating medium in the housing is formed as perforation leading into the inner face.

8. Ball-piston construction for machines and machines incorporating such constructions, substantially as herein described with reference to and as shown in the accompanying drawings.

**DERWENT-ACC-NO:** 1983-754926

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**TITLE:** Ball piston construction for nutating-disc machine has piston mounted obliquely on rotary shaft and having slotted elements engaging radial blades in housing

**INVENTOR:** NAGY G; SZIMAY Z

**PATENT-ASSIGNEE:** SZIRMAY Z[SZIRI]

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DE 3206286 A	September 8, 1983	DE
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**ABSTRACTED-PUB-NO:** GB 2115490 A**BASIC-ABSTRACT:**

The ball piston construction is for a machine of the nutating-disc type that may be used as an engine or a pump. The construction includes an engine or a pump a piston (16) mounted obliquely on a rotary shaft (34). Relative to the shaft the piston can revolve about its own axis t2 while the shaft turns about its axis t1. Slotted elements (21) in the piston are disposed radially and engage slidingly with radial blades (28) fixed in a housing structure (2).

The housing has conic inner surfaces (9) and is either fixed or rotates with the shaft. Ports for the working fluid may be formed in the conic surfaces. Power-transmitting gear-teeth (30) may be attached to the housing structure. When the housing structure is fixed the piston revolves about its axis as it rotates with the shaft and nutates in the housing structure. The piston is fixed relative to the housing structure when the latter rotates with the shaft.

**TITLE-TERMS:** BALL PISTON CONSTRUCTION NUTATING DISC  
MACHINE MOUNT OBLIQUE ROTATING SHAFT  
SLOT ELEMENT ENGAGE RADIAL BLADE  
HOUSING

**DERWENT-CLASS:** Q51 Q55 Q56 Q65